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MEANS OF PLANT DISPERSION.[1]

BY E. J. HILL.

THE paper which is embraced in the following pages can hardly be called one on a subject of microscopy, though to establish some of its facts it requires the aid of the microscope. But the great interest now taken in all biological studies, leads us to look and work beyond the field of view bounded by objectives. They are instruments to help the eye, and are mainly useful when the unaided eye fails to see distinctly. Hence the choice of a subject having a wider range than those ordinarily treated here. The facts presented are mostly those that have come under my own observation, based on an experience of several years of work in field and cabinet, and may be easily verified by any one so disposed, even if not already familiar. They are chiefly confined to our own flora, that the paper may have a local interest, although many instructive illustrations might be cited from the writings of others. They are also limited to the propagation of plants by means of fruit, seed and spore, or analogous substitutes for these, and to their adaptations and the agents that act upon them to accomplish this result. The agency of man is excluded except in so far as it may be unintentional, or merely accidental, as in the case of any animal. It is to the means of dissemination found in nature, of which the plant may avail itself, that the subject will be restricted.

It is one that has to some extent received attention from botanists, though in the main incidentally. Near the close of the last century Joseph Gaertner published his great carpological work, "De Fructibus et Seminibus Plantarum," in which the fruits and seeds of more than a thousand species of plants were described and figured, and among them many curious contrivances, but without specifying their use to the plant. It became a classical work on morphology, and had its influence on the natural classification of plants. A. P. DeCandolle, in his work, "Physiologie végétale," and Alphonse DeCandolle, in his "Géographie botanique raisonée," paid considerable attention to this subject, and have recorded observations of much interest. Among the Germans may be named Naegeli and Kerner, and of Italians, Delpino, as students of these phenomena. They did not escape the notice of so careful an observer as Darwin. But the stimulus of his writings has had a greater effect in directing the mind to them than any extended observations of his own. The best and most complete treatise we have seen, is that of Dr. Friedrich Hildebrand, of Freiburg, "Die Verbreitungsmittel der Pflanzen, Leipzig, 1873."[1] In this small volume of one hundred and sixty pages he brings together a great number of interesting facts, systematically arranged, and accompanies them with several illustrative figures. Since, as already stated, the plan of this paper mainly contemplates those facts that have come under my own observation, his work will be used only in a most general way. There is enough in our flora to illustrate all the most important characteristics of fruits and seeds, and the contrivances and agencies for their dispersion and propagation as noticed by him, so that there is no need of resorting to the flora of the world to find them.

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[1] Read at the monthly meeting of the State Microscopical Society of Illinois, Chicago, Jan. 12, 1883.

The subject is naturally divided into four parts, both as to adaptations of structure and agents for distribution. The agents are the wind, water and animals, for each of which are found contrivances suited to these modes of spreading. There is a fourth class, dependent on special movements in the plant itself. Each of these topics will be considered in order.

I. In examining plants with reference to modes of distribution, the agency of the wind is the most obvious and universal. The means to secure this result are quite various in kind, and are mostly comprised in two divisions, adaptations of fruit and adaptations of seed.

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[1] To this I am indebted for some of the facts of this paragraph, as well as to Sach's Geschichte der Botanik, München, 1875.

In contrivances for scattering fruits or seeds by wind agency, it is plain that their mass must be relatively small and light, or if large or heavy the buoyant part must predominate. The problem is to overcome the lightness of the air by a substance specifically heavier, which may, however, by the aid of currents of air acting on some equipment, be wafted away from the parent stock. The germ of a new plant may in this way be taken up and carried a few feet or yards, or even many miles. The modifications of fruit to secure this end will be noticed first, some of the most common examples being taken for illustration.

The samara, or key-fruit of the maple, is a familiar case. When the key is double, as in the common maples and Negundo, each part has a striking resemblance to the wing of an insect, being thicker and narrower at the base, thinner and broader at the top. In the ash the wing has a spatulate form; in the elm and birch it is oval, the wing encircling the fruit. In the hop tree (*Ptelea trifoliata*) it is similar, being almost circular. A contrivance much like a samara is found in Liriodendron, the tulip tree. The numerous pistils of a single flower are attached to a common axis, making a cone-shaped collection as a whole. Each carpel is furnished with a wing, pointing upward along the axis, and as they fall away separately they may be taken and borne off by the wind. If the fall of the samara, or key-fruit of the maple or ash be watched, the usefulness of this appendage is easily discerned. It falls with a whirling motion, like a stone with a shingle tied to it, and may be carried to quite a distance even by a slight breeze, and much farther if the wind be high.

Smaller but similar growths from the fruit are found in some of the Umbelliferæ, as in the carrot, parsnip, cow parsnip (*Heracleum lanatum*), Polytænia, Archemora and Archangelica. In these the achenia are more or less winged, as may be seen in the so-called seeds of the carrot and parsnip of the shops.

Here also must be placed that adaptation for dispersion seen in the common basswood (Tilia), a bract growing from the peduncle. In form like the wing of a samara, it serves to carry the nuts attached to the lower end of the stem and its branches, away from the parent tree, and its gyrations while doing so are rather peculiar and complicated. In the hop hornbeam (*Ostrya virginica*) and the blue beech (*Carpinus americanus*), the enlarged bracts of the involucre, becoming dry when the fruit ripens, serve to bear away the masses of fruit they enclose. And the large membranaceous and inflated pod of the bladder-nut (*Staphylea trifolia*), a common shrub in rich open woods, is a kind of natural balloon, readily made the sport of the wind.

As attachments to the end of fruits some good examples are found in the Ranunculus family, in the tailed fruits of Clematis and *Anemone patens.* The autumnal beauty of the virgin's bower (*Clematis virginiana*) when these white plumes are fully formed, quite equals that of its profusion of white blossoms in the summer, and exceeds it in interest. Beauty and utility are here combined in the plan for dispersion by the wind. And one hardly knows which to admire most, the broad purple eye of the pasque flower (*Anemone patens*) dotting the prairies and hillsides of the North in early spring, or its head of fruit, white with feathery tails, seen at a later day. Some of the humbler anemones, such as *A. caroliniana, cylindrica* and *virginiana,* with fruit thickly clothed in matted wool, are well provided with means of dispersion by wind agency.

But the best contrivance for this mode of spreading is the downy or feathery attachment to fruits, called pappus. Morphologically it is a modified calyx; this, adhering to the ovary, rises above it in a tuft of hairs or some kindred form in the place of sepals. Its prevalence in the numerous genera of the great order Compositæ is a marked characteristic of these plants. In some, as Aster, Solidago, Erigeron, Vernonia, it is so short as not to be very efficient for conveyance to any distance, though it furnishes considerable aid, and must not be passed by as unimportant. Its most remarkable development is in the dandelion, thistle, fire-weed (*Erechthites*), Lactuca and Sonchus. Generally it consists of a copious tuft of hairs attached to the top of the achenium, and radiating so as to form a spheric or hemispheric mass. Sometimes, as in the dandelion, the calyx tube is prolonged into a stipe when the fruit matures. This, dividing and spreading at the top, makes a globular head of hairs. That a downy head like this serves its purpose well will be affirmed by all who, on a windy day, have seen the air in the vicinity of a luxuriant growth of thistles filled with their light forms of fruit speeding away to distant fields. Far as the eye can discern them they may be seen, each with its tiny freight of fruit. Rivers and lakes, forests, hills and mountains do not offer an insurmountable barrier to their course, since they are able to pass over them. The way in which the scales of the floral involucre open, facilitates the process. When green they are more or less closely appressed to the head of flowers; when ripe they become dry and spread in a horizontal plane, or become reflexed. This exposes the fruit to the ready access of the wind, and it is easily lifted from its seat on the receptacle.

In the valerians, two species of which are found in our limits, *Valeriana edulis* and *V. sylvatica*, a modified calyx also serves this purpose. Being persistent and coherent with the one-celled and one-seeded ovary, its limb divides into several plumose bristles, much like a pappus; these, rolled inward in the flowers, unroll and spread as the fruit matures.

Among the endogens are found a few of these equipments. In Typha, the common cat-tail rush, the ovaries are surrounded with bristles, making the abundant down of the fruit, and adapting it to wind dissemination.

In the sedge family are some examples of fruit adjusted to this end, principally in Eriophorum, or cotton-grass, and in two species of Scirpus, *S. lineatus* and *S. eriophorum.* Three species of Eriophorum are common about Lake Michigan (*E. virginicum*, *E. polystachyon* and *E. gracile*) in marshes and wet prairies, and may easily be detected among the surrounding plants in summer and early autumn by their cottony heads. The bristles which form the perianth, generally short in other genera and species of this family, lengthen greatly in the cotton-grass, in some cases to an inch, becoming enlarged and numerous. The construction in Scirpus is similar but not so marked.

The beards and awns of grasses will, to some extent, serve the same purpose. Such as have them possess an instrument for catching the wind, and the grain is likely to be more effectually scattered than in the case of those devoid of them. The common reed (*Phragmites communis*) has the rachis of the spikelets of its ample panicle prominently bearded with soft hairs just below the spikelets, which are easily detached when ripe. The whole appearance is like a plume, and either as a whole or in parts is a light object that may be blown about by the wind. In Calamagrostis and Erianthus, there is an analogous arrangement. The spikes of *Hordeum jubatum*, or squirrel tail grass, of Setaria, Gymnostichum and Andropogon are also aided by their hairs and awns. The grain of Stipa is scattered around the plant by the wind, the long awn, aiding in this as well as in directing it, point downward, like a dart to the earth, and pushes the backwardly roughened point into the sand, the grain boring its way in as the awn twists and untwists according to varying conditions of moisture.

Seeds also possess contrivances for dispersion analogous to those already described for fruits. There are seeds with wings, with tufts of hairs at the end, with cottony fibers imbedding them.

Some of the best examples of winged seeds are found in the Coniferæ, particularly the pine and fir. The seeds of these, either singly or in twos, are attached to the inner sides of the scales of the cones, which, when ripe, open so that the seeds may easily fall out or be detached by the wind. The Bignonia family has good representatives of this mode. When the pod of the catalpa opens, winged seeds are found, the wings being cut into a fringe. *Bignonia capreolata* and *Tecoma radicans*, the latter common in cultivation as the trumpet-creeper, are also provided with winged seeds. In some of the smaller plants, as in species of Arabis (*A. lævigata* and *A. canadensis*) the little seeds have a broad wing that materially helps their dispersion when the pod dehisces.

The analogues of fruit with pappus are seeds with a coma, or tuft of hairs. Some of the best illustrations are those of Asclepias and Apocynum. The silky down of the seeds of the silkweed, or milk-weed (Asclepias) forms as efficient a means of spreading by wind agency as the hairs of the thistle or dandelion. The hairs are fully developed as soon as the pod is ripe and ready to open, and are so closely packed that on its opening they bulge out in a fluffy mass like those in the boll of the cotton plant, also a good example of a similar provision. The seeds of Asclepias are also very flat and margined, so as to come under the head of those furnished with a wing, being thus doubly provided with wind adaptations. The willow-herbs (Epilobium) also have seeds with a tuft of hair at the end. The most common and showy of these, *Epilobium angustifolium*, often called fire-weed from its habit of springing up from ground recently burnt over by fire, is thus able to spread with rapidity, like its congener, *Erechthites hieracifolia*, of the Compositæ, also called fire-weed from the same habit.

In the willows and poplars the seed is enveloped in cottony fibers, as in the cotton plant, rendering it very buoyant. The air around a cottonwood tree (*Populus monilifera*) is well filled with these whitened objects, like little bunches of cotton, on a windy day in spring or early summer, when the pods open, thus verifying its popular name.

In scattering the spores of cryptogams currents of air act in a most effectual manner. The spores of the vascular cryptogams, and of mosses, lichens and fungi, as fine as dust, can be carried by the winds as readily as dust, and lodged in any soil suitable for growth. In this respect they are like the pollen of wind-fertilized flowers. Since many of these plants are parasites, and injurious to animal and vegetable life, as well as beneficial in some cases in keeping in check forms even more destructive, their mode of diffusion offers a field of investigation of the greatest practical importance. If the germ theory of disease be true, the physician can find in the air one of the most efficient instruments for spreading disease.

Many small seeds that have no special contrivance to secure their dispersion are blown away from the parent plant. Their intrinsic lightness is an adequate adaptation, as in the case of spores. The only peculiarity may be in the pod itself, in its mode of dehiscence, or way of exposing the seed. It may open so that the wind has free access to the seed; or the seed may be caught in the act of falling and turned from its course. In the mustard family the valves of the pods sometimes, as in Arabis, loosen at the base and turn upward, thus exposing the seeds as they hang in the partition between the valves. A loculicidal dehiscence or splitting of the wall of a capsule so as to open directly into a cell, favors this result. In the pink family the pod splits up into several parts, often ten, effectually exposing the small seeds. As seeds thus to be dispersed by wind agency, may be mentioned those of figworts (Scrofulariaceæ), primroses (Primulaceæ), poppies (Papaveraceæ) and gentians (Gentianaceæ), a list that might be much extended.

Nor should we limit the power of the wind in spreading fruits and seeds to the lighter kinds, for it has an important effect on the larger and heavier. As they mostly ripen at the time of the year when the winds are usually strongest and often shifting in direction, nuts and heavy fruits are blown to a considerable distance around the tree on which they grow. They do not fall vertically as when the air is still, but are deflected from this course. All who remember their childhood experience in gathering nuts, will confirm this. They were not all found beneath the particular tree that bore them. In this way the heaviest of the forest fruits, like those of the butternut, walnut, hickory, chestnut, beech and oak, are quite extensively scattered.

Plants are also blown about as a whole or in bulk, or their fruiting branches are thus blown. This is not uncommon with grasses having capillary panicles. In this way species of Panicum (witch-grass) and Eragrostis are sent whirling over the fields in autumn, and are often seen piled against a fence, or the windward side of any obstacle by which they have been stopped. The same is also true of many other plants. Some of our common weeds are dispersed in this way. One example is in point. I have often watched with interest the movements of a weed abundant in gardens and cultivated fields, *Amarantus albus.* It is rightly named in some localities the *tumble-weed.* The diameter of a well-grown specimen is rather more than its height, the stems spreading in all directions from the short tap root. Soon turning upward at the ends, they make a bushy weed of a roundish form. When ripe and dry the constant tugging of the wind tears it from the soil and sends it rolling and bounding across the fields, much like a hat blown from the head. This constant jarring threshes out the seed that may have resisted gentler treatment, and sows it broadcast over the fields to annoy the farmer the coming year. They are sometimes piled fence high in some of the large fields of prairie farms, to be blown away again in the opposite direction when the wind changes and dislodges them from their place of temporary rest.

II. The second group of adaptations depends for its efficiency on the agency of water. The limits of this paper will not permit the enumeration of the various plants that may, in different degrees, be aided in this way. If the germ is sufficiently protected from injury while in the water, from germination or destruction before reaching a place suitable for growth, this means of transfer may be available in a large number of cases. It is evident that islands have in this manner, and by the aid of winds and animals, often or even mainly obtained their species of plants, usually like those of adjacent shores. The similarity of their flora to that of the mainland near by is a proof of this, since many of their plants could have been received in no other way, unless the islands have been at some former era physically joined to the continents, and afterward cut off by water through subsidence. Hard fruits like walnuts, butternuts and acorns readily bear this transportation, and their thickened coats serve not only to keep the water from injuring the germ, but also help to float them by rendering them lighter in proportion to the water displaced. So too with hard seeds that may be dropped into the water by plants which grow along its margin. In this way streams, and currents on ponds, lakes and arms of the sea, aided by winds that drift bodies along the surface of the water, bear their freight of seeds and fruits from land-grown plants.

But aquatic plants, whose fruits and seeds ultimately sink in water, must be principally dispersed in this manner. They generally grow in the stiller parts of streams and sheltered places of ponds and lakes, and their seeds are borne away by currents or drifted by winds till lodged or dropped in quiet spots. Sometimes there are special equipments to facilitate this, like wings or other floats, such as are also suitable for wind transportation. A good example of this is the fruit of the common arrow-head (Sagittaria), which, surrounded by a wing, easily floats away on the water. The flattened spikelets of aquatic grasses, like Leersia, and the inflated perigynea of many sedges of the genus Carex, as well as the bristles that surround the fruit of some, like Eleocharis, contribute to this result. It is a common thing to see plants floated off wholly or in part by water. The current of any stream shows this. The shores of ponds and lakes, and the banks of rivers are often strewn with species of the plants that grow in them. By their examination the collector learns what may be found in them even before seeking for their particular location. If torn from their place of growth at the time of ripened fruit, this becomes an effectual means of propagation. Stems of Potamogeton and other Naidaceæ, of Myriophyllum and Ceratophyllum, carry their seed in this way. This is especially true of some plants that are rootless and float naturally on the surface, like the Utriculariæ, or bladder-worts, some of which are provided with bladders to sustain them on the water. The duckweed (Lemna) and Wolffiia are in this manner carried everywhere in the waters they frequent, till they find some quiet place where they can multiply and propagate themselves. The same is true of the great family of Algæ. As the air is the natural medium for scattering the spores of terrestrial cryptogams, so the water is for the spores of aquatic cryptogams. In some the spores are furnished with a vibratile filament, a tail-like appendage that moves them about like analogous organs in the flagellate Infusoria. Desmids and Diatoms are found in all our waters, the sport of the waves and currents. And as the majority of the Algæ are unattached, floating plants, they will be transported wholly or in part to all parts of the medium they inhabit.

(To be continued.)

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ON THE CLASSIFICATION OF THE LINNÆAN ORDERS OF ORTHOPTERA AND NEUROPTERA.

BY A. S. PACKARD, JR.

IN the forthcoming third report of the U. S. Entomological Commission, we have endeavored to ascertain the position of the Orthoptera in reference to allied ametabolous insects. The following pages are extracted from the chapter, with some omissions:

We have examined the fundamental characters of the head, thorax and abdomen, points neglected by most systematic writers, not spending much time on the peripheral, *i. e.*, the superficial adaptive characters of the mouth-parts, wings and legs, which have been elaborated by systematic entomologists; believing that by this method perhaps more thorough and better grounded views might result. The outcome has been to lead us to separate the Neuroptera, as defined farther on, from the Pseudoneuroptera, and to regard these two groups, with the Orthoptera and Dermatoptera, as four orders of a category which may be regarded as a superorder, for which the name Phyloptera is proposed, as these four orders are probably closely allied to, if not in some cases identical with, the stem or ancestral groups from which probably all the higher orders—the Hemiptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera—have originated.

We will first briefly summarize the characters, as we understand them, of the Phyloptera as a whole; then the distinguishing marks of the four orders.